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ABSTRACT

Two groups of English speakers received either auditory or articulatory instruction in learning to produce exotic sounds. Performance on production and discrimination tests indicated a striking superiority for the subjects who received systematic training in the production of exotic sounds as opposed to those subjects who received only discrimination training in listening to these sounds. The results of this study suggest that what is effective in the teaching of sound production and discrimination is the systematic development by small steps from known articulatory postures and movements to new and unknown ones. The possession of a scientific knowledge of articulatory phonetics by the teacher was shown to be extremely successful in leading students to the correct production of foreign sounds and thereafter to facilitate the discrimination of these sounds. The latter finding was taken as support for some carry-over from productive competence to auditory discriminatory competence. (Author/FWB)

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AUDITORY VS. ARTICULATORY TRAINING IN EXOTIC SOUNDS[1]

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Two groups of English speakers received either auditory or articulatory instruction in learning to produce exotic sounds. Performance on production and discrimination tests indicated a striking superiority for the subjects who received systematic training in the production of exotic sounds as opposed to those subjects who received only discrimination training in listening to these sounds. The results of this study suggest that what is effective in the teaching of sound production and discrimination is the systematic development by small steps from known articulatory postures and movements to new and unknown ones. The possession of a scientific knowledge of articulatory phonetics by the teacher was shown to be extremely successful in leading students to the correct production of foreign sounds and thereafter to facilitate the discrimination of these sounds. The latter finding was taken as support for some carry-over from productive competence to auditory discriminatory competence.

Some seven years ago, John B. Carroll wrote as follows on the teaching of foreign language phonology:

> Speculation among linguists seems to run to an almost schizoid indecision as to which of two diametrically opposed theories to accept: (1) that there is an automatic capacity to form the correct modes of sound production simply by careful and repeated listening--as if the learner is already "wired" to pronounce sounds correctly if he will only give full rein to this automatic capacity, or (2) that (except possibly for the young child) the learning of a foreign phoneme occurs as a result of conscious attention to the articulatory processes involved in its production, and that a scientific knowledge of articulatory phonetics is a positive aid (Carroll, 1963, p. 1070).

At that time there were few relevant research results available, and Carroll added: "We have a rather neat experimental problem which urgently needs exploration." The problem has not so far received this exploration. A few studies have appeared which are only partly relevant. Mueller and Niedzielski (1968) suggest that training in auditory discrimination "seems to be an effective device in the learning of pronunciation," though, in fact, their results were significant for only three out of seven variables examined.

Henning (1964) in another study involving both discrimination training and pronunciation practice states that "the subjects who received discrimination training without pronunciation practice were able to pronounce the sounds of French with greater accuracy than those who received pronunciation practice without discrimination training." This result seems to support Carroll's theory (1) above; however, closer examination of Henning's experiment reveals that the "pronunciation practice" which his subjects received was not, in fact, any kind of systematic training in sound production. "Pronunciation practice" writes Henning (p. 33) "took the form of simple mimicry of the sounds in a wide variety of phonetic contexts, and substitution of the sound being drilled for another one, again in a variety of phonetic contexts." This experiment, then, tells us nothing about the relative efficacy of systematic discrimination training versus systematic production training.

The present study comes a little nearer to resolving the question posed by Carroll, though it must be pointed out that, dealing as it does with only a small number of subjects, it should, perhaps, be regarded as a pilot experiment--even though its results are strikingly significant. Moreover, the hypothesis--"that a scientific knowledge of articulatory phonetics is a positive aid"--is interpreted in the present study to mean the possession of such knowledge (and the associated motor skills) on the part of the <u>teacher</u>, such knowledge enabling him to lead the students step by step into the correct production of foreign sounds.

Method

In the present experiment, two groups of subjects, A and B, were each taught a number of "exotic" sounds (and the appropriate phonetic symbols for them) using two quite different techniques which we may call <u>articulatory</u> instruction for Group A, and <u>auditory</u> instruction for Group B.

The exotic sounds which were taught were the following:

ç voiceless dorso-palatal fricative

ɬ voiceless apico-alveolar lateral fricative

ɢ voiceless dorso-uvular stop

ʔ glottal stop

ᵏ glottalic egressive dorso-velar stop ("glottalised k")

y close front rounded vowel

ø half-close front rounded vowel

ɯ close back unrounded vowel

In both teaching modes these exotic sounds were also compared and contrasted with the following familiar sounds: the consonants s ʃ l k and the (more or less cardinal) vowels i e a o u.

Subjects

The subjects were 14 undergraduate students at The University of Michigan. There were 8 subjects in Group A and 6 subjects in Group B. It was intended to use larger numbers, but as it happened, it was extremely difficult to find a large number of subjects with the required qualifications--native speakers of English with no history of speech impairment or hearing disorders and no knowledge of French, German, or Russian (since some of the "exotic" sounds, or sounds closely resembling them, occur in these languages). All subjects were paid for their services.

Procedure

Each training session took place on a Saturday morning and lasted approximately two hours, with a break in the middle. The training session was followed, after a short break, by an auditory discrimination test. This consisted of 50 disyllabic items of the type aCV (e.g., aʁe aɬy, etc.), incorporating all the exotic and familiar sounds in various combinations (see Appendices A, B, and C). The initial a- in the test items was there merely to bring the C into an intervocalic position, mainly to facilitate making the distinction between glottal stop and zero as in [aʔe] versus [ae]. Each item thus consisted of two segmental sounds to be identified (including "zero sound" in the case of [ae], etc.). The maximum score obtainable in the 50-item test was thus 100. Subjects were presented with a sheet setting forth the phonetic symbols (which they had learned) to which they could refer during the discrimination test. The reference sheet given to Group A defined the symbols in articulatory terms since they had been made aware of the articulatory characteristics of the sounds; that given to Group B, however, could provide no such definitions but merely listed the symbols in an order which placed more or less similar exotic and non-exotic sounds near each other.

After a lunch break the subjects returned and were interviewed individually. They were asked to pronounce syllables (presented to them in phonetic transcription) containing all the exotic sounds. Their performance on this task was evaluated simultaneously by two phoneticians[2] who scored their performance of

each sound on the following scale:

2 (perfect or near-perfect);

1 (a fairly good approximation, or a near-perfect performance but only after several attempts); and

0 (failure to produce even a fairly good approximation to the required sound).

Each group of subjects as indicated above received the same amount of training, and identical discrimination and production tests. The crucial difference lay in the technique of training.

Training techniques

Group A was given purely articulatory training, that is to say, subjects were induced, by passing systematically from known to unknown articulatory postures and movements, to produce the exotic sounds. They were given minimal auditory exposure to the sounds, they carried out a good deal of silent practice (the best technique for consolidating motor control), and for nearly every "exotic" sound they did not hear the sound at all until they themselves produced it. They arrived at the correct articulation purely by following articulatory instructions and procedures. For example, after a few minutes of intensive training in voicing (i.e., consciously taking "voice" away from voiced sound and adding voice to voiceless ones), they immediately acquired [ç] by de-voicing an [i] vowel and [ɬ] by devoicing an [l]. They learned [q] by silently articulating [k] several times, then silently holding the k-closure and sliding the tongue back and down, then releasing the stop from there. The glottal stop was, of course, learned by "holding the breath," and the glottalic egressive ("ejective" or "glottalised") [ƙ] was developed from [k] plus [ʔ]. How this was done is perhaps best indicated by a quotation from the transcript of the recording which was made of the actual teaching. The glottal stop [ʔ] has just been taught.

> Teacher: Now the next thing I want is to make you combine this: "k," with this "ʔ". That's to say, I'm going to ask you to keep your glottis closed, and while the glottis is closed, to produce a sort of k-sound. Now I'm not going to do it, because I don't want you to hear it. I want you to discover for yourselves what happens.
>
> First of all I want you to hold the glottis closed for a considerable period...and when I say "considerable" I mean something like this [hʔ...(4 seconds)...ʔh]. Now while you're doing that, while you're holding your glottis closed, I want you, right in the middle...while

keeping it closed...to make a k-type closure, a closure between the back of the tongue and the soft palate...then release the k-closure before you release the glottis. Try to do that now.

Close the glottis and hold it closed.
Make the k-closure.
Release the k-closure (some correct glottalised k's can be heard).
Release the glottis.
Now we're getting to it. Notice that if you produce any sound at all with that k-closure it'll be something like this--[kˈ]. Now do it again.

Naturally, subjects could not be prevented from hearing the sounds produced by themselves or the teacher, but, as indicated here, the emphasis throughout was entirely on the articulations--and a good deal of practice was done silently.

The rounded vowels [y] and [ø] were learned, after some preliminary silent training in rounding and unrounding the lips, by holding a rounded lip-posture and saying [i] or [e] respectively. Unrounded [ɯ] was learned, conversely, (a) by silently holding a wide unrounded lip position and then trying to say [u]; (b) by starting from a silent [u], then, in silence, slowly and deliberately unrounding the lips, while concentrating on maintaining the tongue-articulation of [u].

Group B subjects were given purely auditory training--that is to say, they were made to listen repeatedly to the exotic sounds, and to very frequent comparisons between these sounds and between exotic and familiar sounds. After each short session of listening to a new sound, alone and paired with other sounds, they were asked to mimic the new sound. They received some individual attention (as did members of Group A) being told when their attempts were far off, close, or exactly right. Throughout, however, no information was given about the articulation of the sounds--except that the teacher at one point accidentally referred to [ʔ] as representing a "glottal stop", which may have been an articulatory clue for the subjects, although this was doubtful, since none of the 14 subjects had taken any linguistics or phonetics courses. Moreover, during the training period, whenever the teacher was presenting or drilling sounds, his mouth was covered by a perforated screen, so that subjects could not see lip positions.

Results

A summary of the proportion of correct responses in the production task and the discrimination test for both Group A and Group B is presented in Table 1.

Insert Table 1 about here

Inspection of this table reveals that Group A (Articulatory Instruction) scored higher than Group B (Auditory Instruction) on every dependent measure examined. Figure 1 shows the overall percent correct scores on production and

---
Insert Figure 1 about here
---

discrimination for Group A or Group B. In order to determine whether the differences between these two groups were due to chance a series of 2 x 2 Chi-square tests was applied to the production and discrimination scores. Chi-square was chosen as the appropriate statistic because the obtained scores for both production and discrimination tests were judgments of correct or incorrect responses. As it happens, the 2 x 2 Chi-square test is also equivalent to testing the significance of the difference between two proportions (see Walker & Lev, 1953, pp. 78 & 106), i.e., Group A vs. Group B.

The results of the Chi-square tests for overall production and production of vowels and consonants separately and a similar analysis for the discrimination measures is presented in Table 2.

Insert Table 2 about here

Group A scored significantly higher than Group B on the overall production and discrimination of the test items. On the production task, Group A was significantly better than Group B on both exotic consonants and exotic vowels. On the discrimination test, Group A scored significantly higher than Group B on all classes of sounds except the non-exotic consonants and exotic consonants when considered separately. However, when the consonants are combined, Group A still discriminated significantly more consonants than Group B ($p < .05$).

Discussion

In the present experiment, as we have seen, Group A who received articulatory training performed more than twice as well, in the production test, as Group B, with only auditory training.

Both groups performed better in the production of exotic <u>consonants</u> than of exotic <u>vowels</u>. For Group A the difference was small, .75 for the consonants compared to .69 for the vowels ($\chi = 9.23$, $p < .01$). These differences were considerably greater for Group B, .42 for the consonants compared to .18 for the vowels ($\chi = 12.91$, $p < .001$). In the discrimination test, as well, Group B

showed greater differences in performance between exotic consonants and exotic vowels than did Group A. Both these results are due in large part to the fact that Group B showed a much greater tendency than Group A to posit incorrect lip positions for vowels--i.e., to misidentify [y] as [i], or [ɯ] as [y], etc. This is not particularly surprising in view of the fact that Group B was never allowed to see lip positions during training (though the lips were visible during discrimination testing) whereas members of Group A not only saw lip positions, but were explicitly taught to add or subtract lip rounding as required in learning [y], [ø], and [ɯ].

A lesson possibly to be learned from this is the inadequacy of any purely auditory tape-recorded pronunciation-training program which relies entirely on mimicry of vowels without supplying explicit information at least on lip positions. This, after all, is one of the very simplest phonetic features to describe and teach, even to people with no phonetic training.

In general, the results clearly vindicate the view that if you want people to produce sounds you must accurately train them to do just that. This would seem to be a truism, but the fact is that, as Carroll implies in the quote at the beginning of this report, there apparently is a current belief that you can teach people to produce sounds by merely making them listen to them. Our results certainly indicate that auditory methods are significantly less effective than teaching production by means of systematic application of articulatory phonetic knowledge. However, this point must be emphasized: what is effective in the teaching of sound-production is the systematic development by small steps from known articulatory postures and movements to new and unknown ones. That is to say, the application of phonetic knowledge by the teacher enables the student to pick up some knowledge of "phonetic theory" <u>inductively</u> as a result of experiencing phonetic activities in his own vocal tract.

If, as we have said, it is not surprising that subjects <u>learn</u> to produce sounds through being <u>taught</u> to produce them, it may indeed appear a little surprising that they thereby also learn to identify them by ear. Our results show that Group A, taught by exclusively articulatory techniques were significantly more successful at identifying sounds by ear than the group taught by purely auditory techniques. This obviously implies some kind of carry-over from productive competence to auditory discriminatory competence, and may, indeed be taken to be some support for a "Motor theory of speech perception" (Liberman, Cooper, Harris, & MacNeilage, 1963). As a matter of fact, it has

been the experience of one of the investigators in a lifetime of teaching phonetics and analyzing languages, that "exotic" sounds can generally be more readily and unerringly identified after one has learned to produce them.

Be that as it may, our investigation indicates that "ear-training" and mimicking alone are less effective than articulatory training in teaching both the auditory discrimination and the production of exotic sounds. It seems to us that these preliminary findings are worthy of additional investigation preferably with a larger group of subjects and with speakers of several different languages.

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July, 1970

Footnotes

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[2]We should like to thank Professor Kenneth Hill of the Department of Linguistics at The University of Michigan for his help in evaluating the subjects' performance on the production tests.

Figure Caption

Fig. 1. Percent correct responses on overall production and discrimination of exotic sounds for Group A and Group B.

Table 1

Proportion of Correct Responses for Group A and Group B in Production and Discrimination of Exotic and Non-Exotic Sounds

Class of Sounds	Group A (N=8)	Group B (N=6)
Overall Production	.73	.32
Exotic consonants	.75	.42
Exotic vowels	.69	.18
Overall Discrimination	.80	.71
Consonants	.77	.71
Exotic consonants	.74	.68
Non-exotic consonants	.80	.74
Vowels	.83	.72
Exotic vowels	.57	.44
Non-exotic vowels	.95	.83

Table 2

Summary of Chi-Square Tests for Group A and Group B in Production and Discrimination of Exotic and Non-Exotic Sounds

	Chi-Square Value	Group	Significance Level
Overall Production	376.00	A > B	$p < .001$
Production of exotic consonants	15.97	A > B	$p < .001$
Production of exotic vowels	21.22	A > B	$p < .001$
Overall Discrimination	14.67	A > B	$p < .001$
Discrimination of consonants	3.24	A > B	$p < .05$
Non-exotic consonants	2.09	A > B	Not significant
Exotic consonants	1.26	A > B	Not significant
Discrimination of vowels	13.53	A > B	$p < .001$
Non-exotic vowels	16.75	A > B	$p < .001$
Exotic vowels	3.07	A > B	$p < .05$

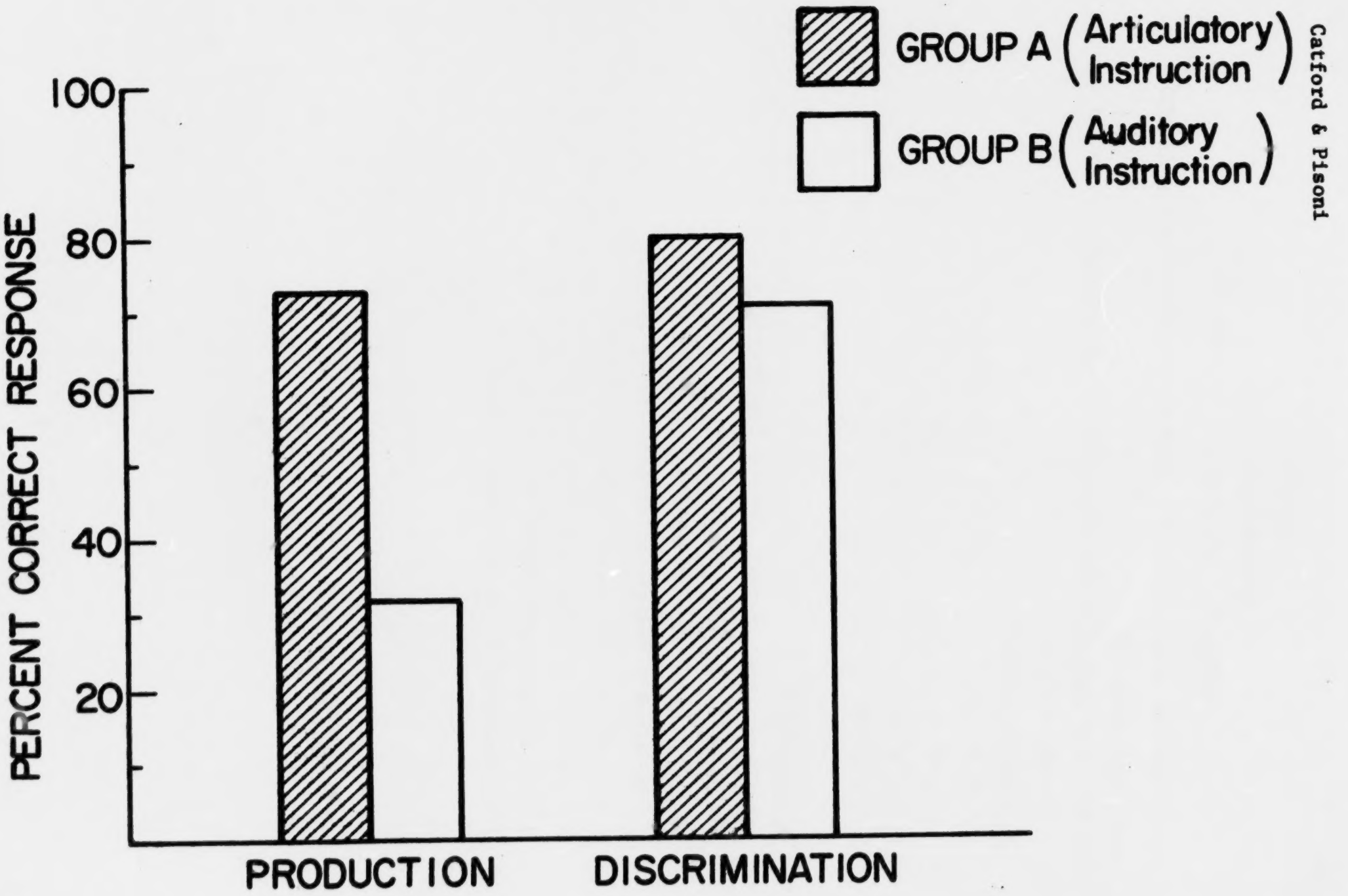
GROUP A (Articulatory Instruction)
GROUP B (Auditory Instruction)
PERCENT CORRECT RESPONSE
100
80
60
40
20
PRODUCTION
DISCRIMINATION

Figure 1

Appendix A

Discrimination Test

(Group A - Articulatory Instruction)

You will hear 50 nonsense "words" each consisting of a + consonant + vowel, e.g., asi, ake, etc.

Write down the consonant and the vowel in the appropriate spaces below, using the following symbols.

1. Non-exotic sounds:

i = ee in see	e = ay in day
o = o in go	u = oo in too
s = s in see	ʃ = sh in she
k = k in key	l = l in lay

2. Exotic sounds:

y = close front rounded vowel (= rounded i)

ø = half-close front rounded vowel (= rounded e)

ɯ = close back unrounded vowel (= unrounded u)

ç = unvoiced i (voiceless palatal fricative)

ɬ = unvoiced (voiceless alveolar lateral)

q = far back k (voiceless uvular stop)

ʔ = "holding breath" (glottal stop)

ʞ = "ejective" k (k with glottal stop)

Appendix B

Discrimination Test

(Group B - Auditory Instruction)

You will hear 50 nonsense "words" each consisting of a + consonant + vowel, e.g., asi, ake, etc.

Write down the consonant and the following vowel in the appropriate spaces on the answer sheet, using the following symbols.

Vowels

Familiar	Exotic	Familiar
i = ee in see	y, ɯ,	u = oo in too
e = ay in day	ø	o = o in go
a a in far		

Consonants

Familiar	Exotic	Familiar
k = k in key	ƙ, q	ʔ = ʔ in ʔuhʔuh
s = s in see	ç	ʃ = sh in she
l = l in lay	ɬ	

Appendix C

Discrimination Test Items for Group A and Group B

Trials a. aço
b. aɬe

1. aço	14. aʔɯ	27. aʔe	40. aʔi
2. aɋi	15. aʃu	28. açu	41. alu
3. asʏ	16. alo	29. ale	42. aɋɯ
4. aʞu	17. aki	30. aʞe	43. açe
5. a#ø	18. aɬi	31. a#u	44. aʞi
6. aso	19. aʔu	32. asɯ	45. a#e
7. akɯ	20. akø	33. aky	46. aɬo
8. aɋe	21. aɋo	34. a#i	47. aɋu
9. açʏ	22. aʃy	35. alø	48. aʔo
10. a#o	23. açi	36. ake	49. alʏ
11. aɬe	24. alo	37. ase	50. aʃi
12. aʞo	25. aɬø	38. aʞø	
13. aʃø	26. asi	39. aɬu	